22/09/2017

Composting of pig slurry –a review

Henrik Bjarne Møller, CSAWMP Consultant, Denmark

Definition

Composting is a traditional management process used to decompose the manure organic matter by microbial aerobic process. The main reasons of composting are to recycle nutrients excreted by animals, stabilize organic matter before its transport and use and reduce manure pathogens (Bernal et al., 2009). Done in static piles with natural aeration composting manure is a low-cost and low-energy process that can be applied on small to medium-sized farms but more advanced systems also exists. Composting is the spontaneous biological decomposition that occurs with degradable organic materials in a predominantly aerobic environment. Compared with natural aerobic decay, composting is a process managed deliberately to speed up the decay, while retaining nutrients in mainly immobilised, organic form and stabilising the more recalcitrant organic compounds. The composting process leads to the production of carbon dioxide (CO2), water, minerals and biologically stabilised (humified) organic matter. The latter, including part of the water and minerals, is called compost, and should be free of weed seeds, phytotoxicity and pathogenic microorganisms.

The process is exothermic and energy is released, which generates a temperature increase in the mass, as long as heat is not lost to the surroundings at a higher rate than heat evolution
Composting involves thermophilic, aerobic degradation of the manure organic matter, followed by a phase where the temperature slowly decreases and complex organic macromolecules are produced (fulvic and humic acids). Aerobic composting of manure is most commonly practiced to overcome some of the problems associated with management of fresh manure. It reduces mass (water evaporation and volatile solids decomposition) and yields a stabilised product that is cheaper to transport and easier to handle and apply. Controlled composting allows the safe storage and transport of the final product, adds value to the product because compost is a more concentrated and uniform product than the manure, and permits easy spreading and thus uniform distribution in the soil. Composting also eliminates animal and human pathogens and weed seeds, and reduces the risks of odour and gaseous emissions after application. The compost can also be used as a fertiliser for pots and as a basis for soil-less substrates (Bernal et al., 2009).

Composting is typically characterized by a short initial mesophilic phase, followed by an intense thermophilic phase, a cooling phase and then a prolonged curing or maturation (Figure 1). Composting is a discontinuous (batch) process resulting from sequential development of different microbial communities, mainly bacteria, Actinomycetes and fungi. These are normally present in the starting material; an inoculum is only needed when the starting material is deficient in microorganisms. Higher organisms, such as microarthropods and compost worms (Eisenia foetida), may also colonise and proliferate in maturing compost that has cooled to ambient temperature or may be used in specialised vermi-composting systems where they are added after the thermophilic phase. They mainly play a role in physically shredding and mixing the constituents, promoting microbial decay.

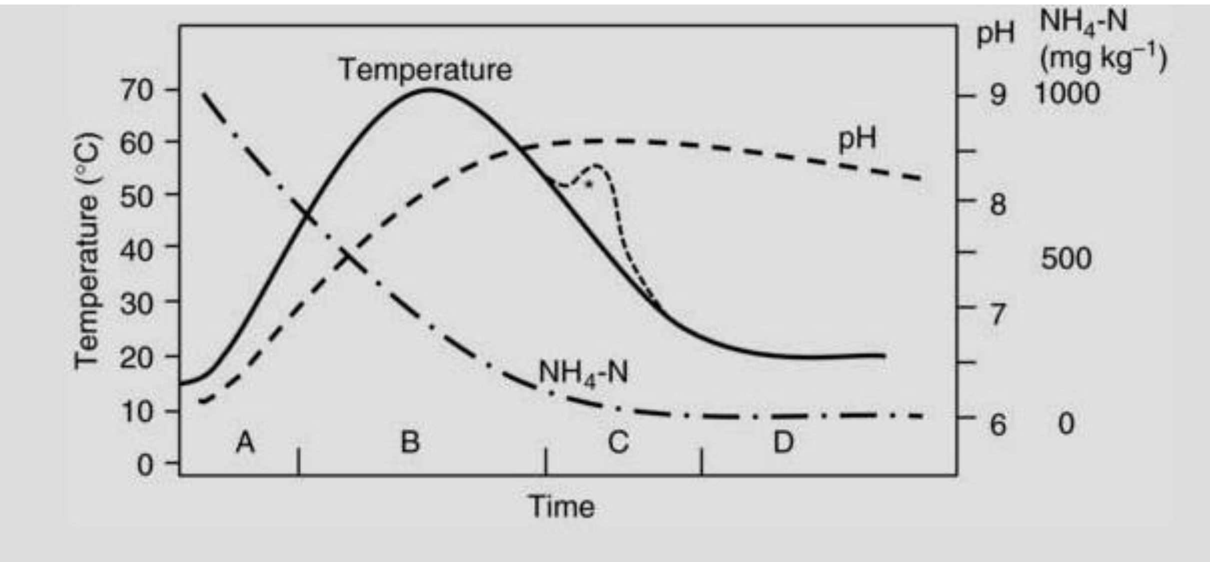

Figure 1. Simplified temperature, pH and NH4+ changes during aerobic composting. Composting phases: (A) mesophilic, (B) thermophilic, (C) cooling and (D) maturation. *Secondary heating peak due to Actinomycete recolonisation and degradation of recalcitrant C can sometimes be observed. Adapted from Sommer et al 2015.

Initial mesophilic phase: The first phase of the composting process is mesophilic (below 45 °C) and starts the aerobic decomposition of easily degradable organic matter, where mesophilic bacteria and fungi degrade simple compounds such as sugars, amino acids, proteins and so on. This rapid decay of material releases a great quantity of energy in the form of heat, which enhances the mass temperature and the degradation rate of the organic waste. Within a few days, this leads to the thermophilic phase.

Thermophilic phase: In this phase, thermophilic microorganisms (mainly bacteria) degrade fats, cellulose, hemicellulose and some lignin, and the maximum degradation of the organic matter occurs, together with the destruction of pathogens. Without control, the temperature can easily reach and exceed 70 °C. The main positive effect of operating at such high temperature is reduction of pathogenic agents present in the waste. In controlled composting processes this phase is limited in terms of temperature and exposure time (degrees and days) to obtain a balance between high stabilisation rates and good sanitisation, often to satisfy local legislation regarding sanitation conditions.

Cooling phase: This phase is characterised by a decrease in temperature due to a reduction in microbial activity associated with the depletion of degradable organic substrates. The composting mass is re-colonised by mesophilic microorganisms, especially Actinomycetes, which are able to degrade the remaining sugars, cellulose and hemicellulose. Sometimes this causes a secondary temperature peak, which is usually short-lived.

Maturation phase: The maturing phase, also called the curing phase, includes not only the mineralisation of slowly degradable molecules, but also the stabilisation and humification of lignocellulosic compounds. This phase can last some weeks to months, depending on the composition of the starting material. During microbial transformation intermediate metabolites are produced, which can make the composting material phytotoxic. These phytotoxic compounds are completely degraded at the end of the maturation process; thereafter, the final product becomes beneficial to plant growth. The composting process should ideally be stopped when the phytotoxicity is over. If the process goes on too long, there is an excessive loss of organic matter, reducing the beneficial impacts of the final product.

Compost optimisation involves the definition of adequate initial substrate conditions that must be controlled and maintained as composting progresses, since they determine the optimal conditions for microbial development and organic matter degradation. The factors affecting the composting process can be divided into two groups: those depending on the formulation of the composting mix, such as nutrient balance, C : N ratio, pH, particle size, porosity and moisture, and those depending on process management, such as oxygen concentration, temperature and water content (Bernal et al., 2009).

Nutritional balance. Mainly defined by the C and N content of the inputs. An adequate C : N ratio for composting is in the range 25–35, and since pig manure has C:N ratios around 10 addition of C rich inputs like straw be added.

Technologies

There is exists different technologies for composting with the following technologies being the most common:

1. Windrow composting
2. In-vessel composting
3. Aerated static pile

Windrow composting is the production of compost by piling organic matter or biodegradable waste, such as animal manure and crop residues, in long rows (*windrows*). This method is suited to producing large volumes of compost. These rows are generally turned to improve porosity and oxygen content, mix in or remove moisture, and redistribute cooler and hotter portions of the pile. Windrow composting is a commonly used farm scale composting method. Composting process control parameters include the initial ratios of carbon and nitrogen rich materials, the amount of bulking agent added to assure air porosity, the pile size, moisture content, and turning frequency.

There exists different types of compost windrow turners. They are traditionally a large machine that straddles a windrow of 1.25 meters or more high. Although smaller machines exist for small windrows, most operations use large machines for volume production. Turners drive through the windrow at a slow rate of forward movement. They have a steel drum with paddles that are rapidly turning. As the turner moves through the windrow, fresh air (oxygen) is injected into the compost by the drum/paddle assembly. The oxygen feeds the aerobic bacteria and thus speeds the composting process. In the figure 2 an example of a GK3000 compost turner is illustrated.

Figure 2: Compost windrow turners

EYS GK3000 Compost Turner is designed to convert dried organic matter (e.g: separated manure) into valuable compost by turning the bulk material periodically. It aerates the windrow for replenished oxygen supply while releasing the CO_2 build-up; breaks down the solid particles to optimum size for increased contact surface; regulates the temperature within the windrow for optimum aerobic reaction speed; and maintains the necessary humidity level evenly within the windrow by its integrated liquid spray system. These features facilitate the chemical reactions that are required for high quality compost.
EYS GK3000 Compost Turner is operated with a tractor via the creep-gear shaft. In transport mode, GK3000 stands up vertically on its transport wheel by means of hydraulic pistons. This allows for increased maneuverability and easy transportation of the machine. GK3000 moves over the windrow at an adjustable speed (0-300m/hr) as defined by the operator. The drum mixes and pushes the material from outside of the pile towards the middle, leaving behind a very neat and well-defined triangular windrow.

Windrows should initially be arranged 3m wide and 1.6m high each. The aisles between each windrow should be 2.5m in order to allow a standard tractor to fit. The ground should be level and smooth for efficient operation of the machine and to ensure uniform windrows (Figure 3).

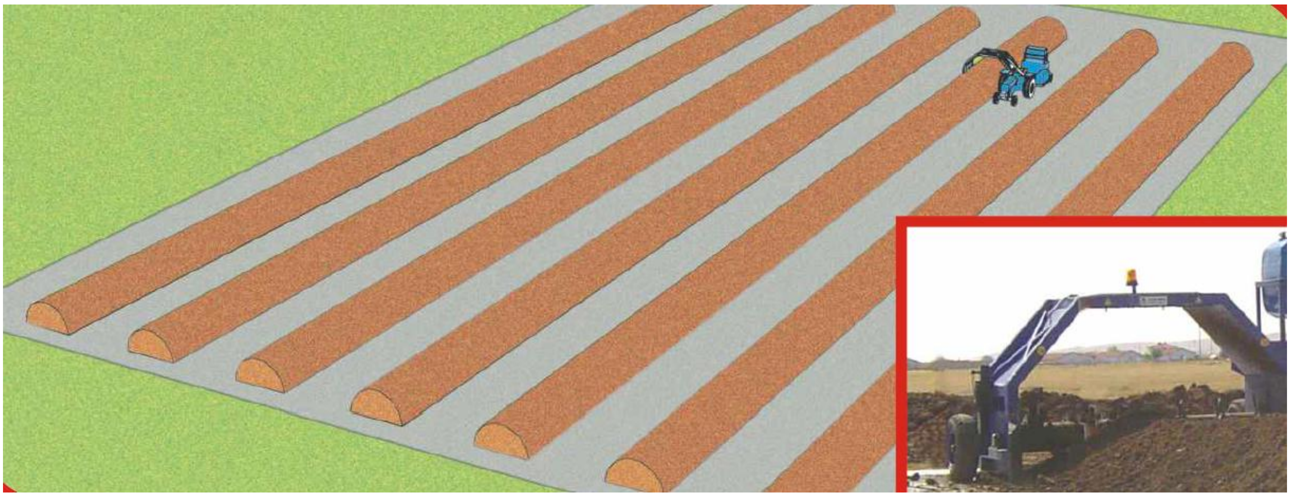

Figure 3: Compost windrows

Instead of a compost turner other machines exists which is stationary and move from the output side towards the input side, the shaft rotates and feed the materials forward to the output side with encouraging the composting by the aeration from agitating. In conjunction with the bacteria decomposition, the temperature of the material goes up to 60-70℃. An example from Bangladesh is shown in Figure 4.

Figure 4: Compost machine for turning compost

In-vessel composting generally describes a group of methods that confine the composting materials within a building, container, or vessel. In-vessel composting systems can consist of metal or plastic tanks or concrete bunkers in which air flow and temperature can be controlled, using the principles of a "bioreactor". Generally the air circulation is metered in via buried tubes that allow fresh air to be injected under pressure, with the exhaust being extracted through a biofilter, with temperature and moisture conditions monitored using probes in the mass to allow maintenance of optimum aerobic decomposition conditions.

This technique is generally used for municipal scale organic waste processing, including final treatment of sewage biosolids, to a safe stable state for reclamation as a soil amendment. There is only few examples where this technique is used for manure.

Aerated Static Pile composting, refers to any of a number of systems used to biodegrade organic material without physical manipulation during primary composting. The blended admixture is usually placed on perforated piping, providing air circulation for controlled aeration . It may be in windrows, open or covered, or in closed containers. With regard to complexity and cost, aerated systems are most commonly used by larger, professionally managed composting facilities, although the technique may range from very small, simple systems to very large, capital intensive, industrial installations.[1]

Aerated static piles offer process control for rapid biodegradation, and work well for facilities processing wet materials and large volumes of feedstocks. ASP facilities can be under roof or outdoor windrow composting operations, or totally enclosed in-vessel composting, sometimes referred to tunnel composting.[2]

The aeration system uses fans to push and/or pull air through the composting mass. Rigid or flexible perforated piping, connected to fans, delivers the air. The pipes can be installed in channels, on top of a floor, or included throughout the pile during buildup (figure 4).

In large-scale systems, forced aeration is accompanied with a computerized monitoring system responsible for controlling the rate and schedule of air delivery to the composting mass, although meters and manual monitoring techniques may also be used in smaller scale operations.

Advantages of this composting method include the ability to maintain the proper moisture and oxygen levels for the microbial populations to operate at peak efficiency to reduce pathogens, while preventing excess heat, which can crash the system.

Figure 4: Example of Aerated Static Pile composting

Litterature:

Sommer Sven G., Morten L. Christensen, Thomas Schmidt, Lars S. Jensen Animal Manure Recycling: Treatment and Management. Wiley. Print ISBN: 9781118488539.

Bernal M.P., J.A. Alburquerque, R. Moral. 2009. Composting of animal manures and chemical criteria for compost maturity assessment. A review. Bioresource Technology 100 (2009) 5444–5453